APPENDIX SS
TRAFFIC SIMULATION MODELING SUMMARY

Traffic Simulation Modeling Summary

Introduction

Most of the traffic analysis needs are met more than adequately by using the I-69 Corridor Model. However, a regional forecasting model looks at traffic behavior in terms of flow density (analogous to a volume of liquid flowing through a conduit) - it does not provide sufficient detail to fully analyze the operation of individual intersections, groups of closely-spaced intersections or interchanges, or freeway merges and diverges.

Simulation models analyze traffic flows at a detailed level (specific intersection and roadway segments) and create traffic flows by modeling the movements of individual vehicles. In a simulation model, traffic is simulated vehicle-by-vehicle so that vehicle interactions between intersections, lanes, and other vehicles are modeled in the operations. In this way the effects of traffic operations at closely spaced intersections can more accurately be evaluated. Simulation analysis also allows for the evaluation of detailed aspects of intersection design, such as the number of lanes and turn lanes, turn lane lengths, and traffic signal operations; such details are not reflected in a regional travel forecasting model.

Simulation analysis offers several benefits that contribute to its ability to analyze detailed vehicle operations. A simulation model's vehicle assignments are probabilistic in nature, meaning that the assignments are based on probabilities for events rather than a strict deterministic forecast. For instance, the exact times that vehicles enter the model can vary from run-to-run under probabilistic assignments, while in deterministic assignments vehicles enter the system at pre-determined times and do not vary. In this way a simulation model shows day-to-day variation in traffic that reflects "heavy" days and "light" days.

Simulation models can also model driver types, driver behaviors, and vehicle fleet mix. A combination of informed and un-informed drivers (i.e., "locals" and "non-locals"), and aggressive and timid drivers, create variations in simulation results. The different vehicle types allow different acceleration and deceleration profiles, which can affect operations at points of conflict such as intersections, interchanges, and ramp merges.

The variation within the vehicle fleet mix, and the ability to assign performance profiles to those vehicles, is also valuable in evaluating the effects of truck traffic on vehicle operations. A number of truck types (light trucks, heavy trucks with four axles, heavy trucks with eight axles, etc.) can be included without the need to convert a truck volume aggregation into a passenger car equivalent (PCE), a common practice with regional forecasting models.

These advantages make traffic simulation modeling an ideal tool to evaluate the traffic operations of closely spaced intersections and interchanges. The ability to simulate vehicular movement between intersections, individual traffic lanes, turn bays, and ramps offers a truer representation of traffic behavior at a more detailed scale. In particular, a simulation model of traffic operations for I-69 Section 5 allows an evaluation of how queuing can propagate delay through the roadway system.

Simulation modeling also offers advantages over more “static” analysis tools for the evaluation of freeway operations. Traditional traffic engineering analysis methodologies often evaluate a freeway segment in isolation. For the reasons enumerated above, a traffic simulation model is a superior analysis tool for a roadway system. This ability is widely recognized throughout the profession and, while isolated analysis can still be useful, simulation modeling has been requested in greater frequency or even required for freeway projects. The Missouri Department of Transportation (MODOT), for example, requires simulation modeling as part of all freeway evaluation projects.

There are simpler methods for performing traffic analysis that have been mentioned above, from the isolated methodology of Highway Capacity Software (HCS) to the deterministic nature of tools such as Synchro. However, it was determined that a traffic simulation model was the best way to address future traffic needs in Section 5.

The I-69 Corridor Model is the primary tool built for forecasting vehicular traffic in Section 5. Since the Corridor Model is a regional travel model, it focuses on regional aspects of the study area and does not model individual vehicle interactions (as described above). Therefore, a microsimulation model was constructed in order to better evaluate the effects of design features on traffic behavior.

This analysis was an important step in finalizing the footprint (and thereby the cost and impacts) of the Section 5 Refined Preferred Alternative. The simulation analysis was coordinated with INDOT, with close collaboration with its Planning staff. Regular meetings (by phone and in person) were conducted to discuss assumptions, methodologies, and progress. These meetings were weekly in the model development stages. Key issues discussed and agreed upon:

- The appropriateness of TransModeler (see below) for this application; both in comparison with other simulation programs such as Paramics, and other types of applications such as Synchro
- The extent of the simulation model network
- Particular areas of interest within the Project
- Inputs to be used from Corridor Model
- Data collection needs

Platform

TransModeler was chosen as the preferred platform to build the microsimulation model. TransModeler is a versatile traffic simulation package that can offer a high level of fidelity in its operations. This means there is a high level of exactness in the movements, decisions, and vehicle behavior that can be included in the simulation runs.

TransModeler also offers direct compatibility with TransCAD (the I-69 Corridor Model platform). TransModeler is designed to readily incorporate network and trip tables from TransCAD (the platform the Corridor Model uses).

Simulation Process

Corridor Model

The I-69 Corridor Model provides inputs to the simulation model. The Corridor Model itself receives input from the Indiana Statewide Travel Demand Model (ISTDM). In 2012, INDOT made a major update to the Indiana Statewide Travel Demand Model (ISTDM). This update produced Version 6 of the ISTDM. The ISTDM is maintained by INDOT to forecast travel patterns on roads maintained and operated by INDOT, as well as other key roads under local jurisdiction. ISTDM travel forecasts are also used by the I-69 Corridor Model to forecast travel for which one or both trip ends are external to the area included in the Corridor Model. The I-69 Corridor Model used in Section 5 includes Sections 5 and 6 of I-69, as well as the major facilities in the state and local road network within the counties served by Sections 5 and 6 and (to a limited extent) in adjacent counties.

Initial versions of ISTDM Version 6 were received by PMC staff in mid-July and mid-September of 2012. These were designated as ISTDM 6v0 and 6v1, respectively. PMC staff identified an underassignment of auto trips within the corridor model area. INDOT's consultant team modified the ISTDM to address these issues. This resulted in the production of an approved ISTDM 6v2 in mid-October. ISTDM 6v2 addressed these underassignment issues by modifying the ISTDM to better reflect actual trip lengths for rural auto trips external to the ISTDM modeled area. In addition, the Corridor Model was used to redistribute ISTDM trips with a trip end within the Corridor Model area.

ISTDM Version 6v2 provides only daily forecasts. Peak hour assignments are needed as input to TransModeler so that precise estimates of facility capacity and Level of Service (LOS) estimates can be developed.

Once it was determined that ISTDM 6v2 was producing daily forecasts within Section 5 of I-69 which appropriately reflected current traffic counts, ISTDM forecasts were used to provide external trips within the I-69 Corridor Model area. This includes internal-external (I-E) trips, external-internal (E-I) trips, and external-external (E-E) trips. The Corridor Model takes daily external auto and truck trips from the ISTDM at its boundary and factors them to AM and PM peak hour trips using percentages from observed data. The Corridor Model then uses these factored peak hour external trips together with peak trip tables internal to the Corridor Model area from a calibrated departure time choice model for autos and an internal truck model to create the peak period assignments within the corridor model boundary[1].

The network and Traffic Analysis Zones (TAZ) structure from the I-69 Corridor Model has been used directly by TransModeler for the simulation-modeled area. While a peak period assignment is completed for the I-69 Corridor Model, the area to be included in TransModeler (including specific links, nodes and centroid connectors) is specified so that the vehicle trips for the simulation model area can be exported for use as inputs to TransModeler (instead of exporting information for the entire Corridor Model network).

Simulation Model

The simulation model includes the SR 37/I-69 corridor within Bloomington (see Figure 1). Through evaluations of future alternatives performed during the DEIS, a preferred build alternative was identified. The simulation model was based on this alternative (Refined Preferred Alternative 8 (RPA 8)).

The model was constructed to analyze traffic operations at the proposed interchanges along I-69 and signalized intersections in the immediate vicinity of the interchanges. Included in the model are RPA 8's interchanges at: Fullerton Pike, Tapp Road, SR 45 (2nd St/Bloomfield Rd), SR 48 (3rd St), SR 46, and Walnut Street. Areas of SR 45 (from Curry Pike to Basswood Drive) and SR 48 (from Curry Pike to Franklin Drive) with signalized intersections near the interchanges were included in the model, as well. Also included in the simulation model was Liberty Drive between 2nd and 3rd Streets. Liberty Drive intersects with these streets at signalized locations and provides the closest viable alternative, parallel route to I-69 in the study area.

[1] See "Peak Hour External Demand" and "Peak Hour Traffic Assignment and Validation" in Section 5 FEIS, Appendix GG ("I-69 Corridor Model Documentation")

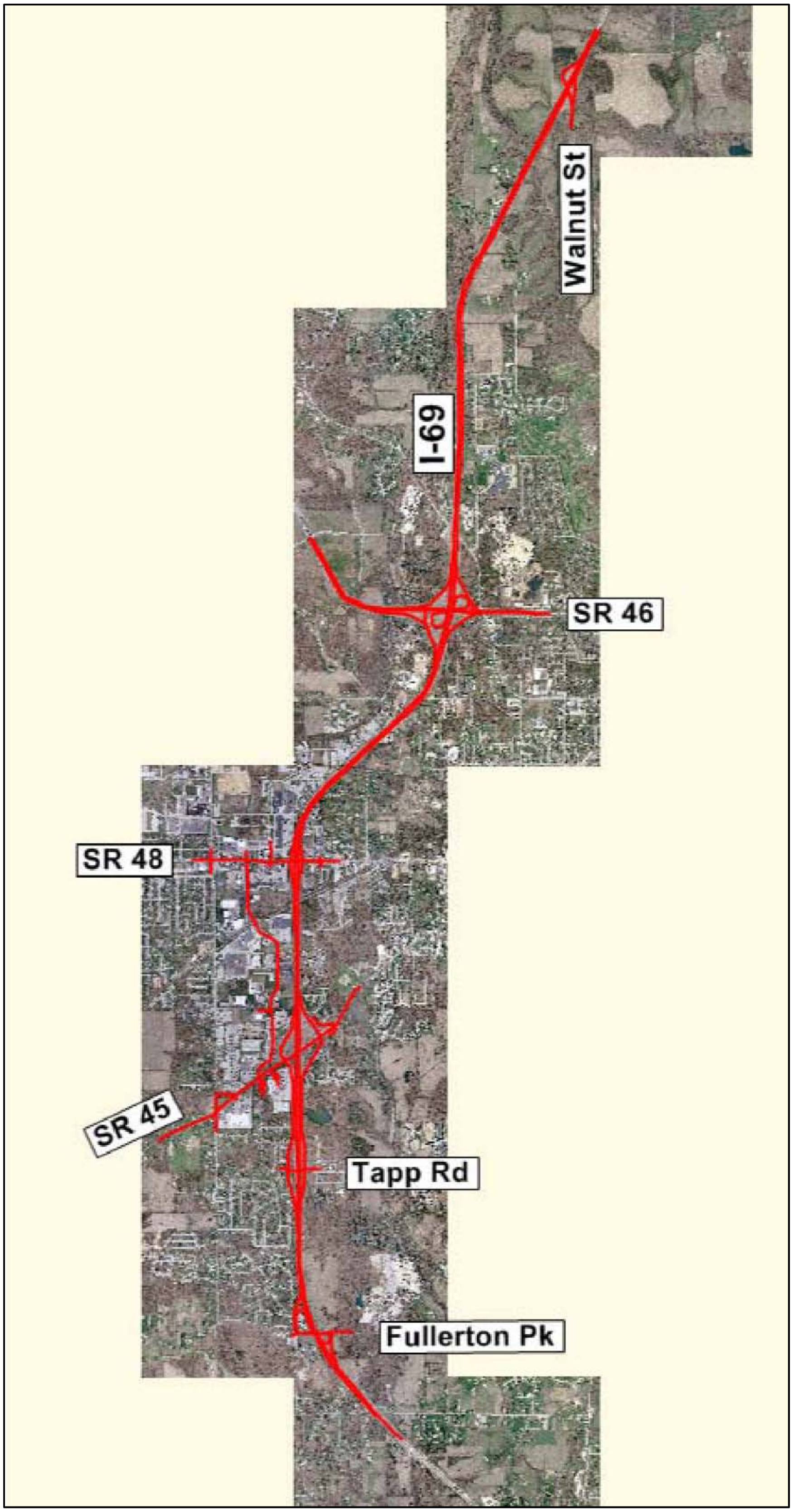

Figure 1: Simulation Study Area

The simulation study area represents a sub-area of the Corridor Model. The Corridor Model vehicle output provided the traffic input to the simulation model. The input was in the form of an origin-destination (o-d) matrix, or trip table. The trip table shows trips to and from locations within the simulation model (the centroids from the Corridor Model) as well as trips into and out of the simulation area. The points within the Corridor Model representing the boundaries of the simulation model were designated as possible origins and destinations for travel. Vehicles crossing between the boundary points or traveling to any internal point were then recorded as desired trips in the origin-destination matrix. By using the o-d trip table as the input into the simulation model, instead of direct vehicle assignment[2], the simulation model would be able to allow vehicles to choose multiple paths through the simulation area (while maintaining the ultimate destination) as traffic conditions warranted.

However, the simulation study area includes more roadway network than is included in the Corridor Model. It is good modeling practice to limit the roads in a regional travel model to roads that could be regionally significant. Unnecessarily increasing the amount of roadway network in a regional travel model increases the computer run time while simultaneously decreasing its accuracy. Therefore, some local roads were not included in the Corridor Model. Some of these local roads are important for the simulation model, given its focused attention on a smaller area.

In order for the Corridor Model to produce an o-d matrix that matched the simulation model, the preferred alternative within the Corridor Model was revised to include additional network. This revision was used to create what can be considered a “special” version of the RPA8 assignment, designed to be used only to provide o-d tables to TransModeler. (The assignments use to produce the TransModeler o-d tables are **not** the RPA8 assignments used to report traffic and performance statistics in the FEIS.) No TAZs were split for this revision. Instead, where appropriate, multiple centroid connectors were added to the model, connecting to stub links representing roadways. The length of the centroid connectors and stubs were manipulated (which affects travel time) to achieve proper assignment on the study area links.

The o-d matrix included volume data for two hours in each peak period. That two hour period included the peak hour with a thirty minute “shoulder” on either side. The simulation model runs start with an empty network (i.e., no vehicles present), and the first thirty minutes of the o-d table (the shoulder) is used to fill the network before evaluation begins. This would ensure that the simulation model would be fully loaded with representative traffic volumes when the peak hour began (and that traffic operations beyond the peak hour could be evaluated, where necessary). Each two-hour matrix was divided into eight fifteen-minute intervals. The

[2] The origin-destination table, as its name implies, is a record of origins and destinations for vehicles within the model. The o-d table does not contain information about the routes chosen to connect the origins and destinations. The process of choosing the routes to travel from origin to destination is part of the vehicle assignment.

percentage of traffic in each interval (as a percentage of the two hour total) was determined using base year traffic counts (see Figures 2 and 3).

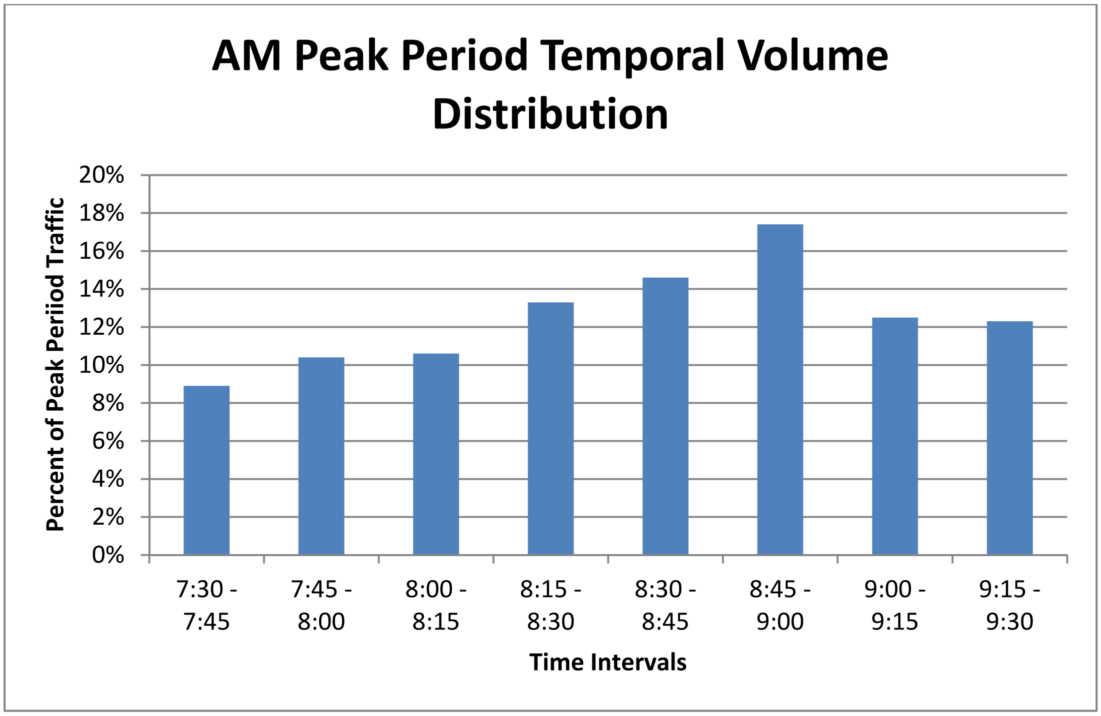

Figure 2: AM Peak Period Traffic Distribution

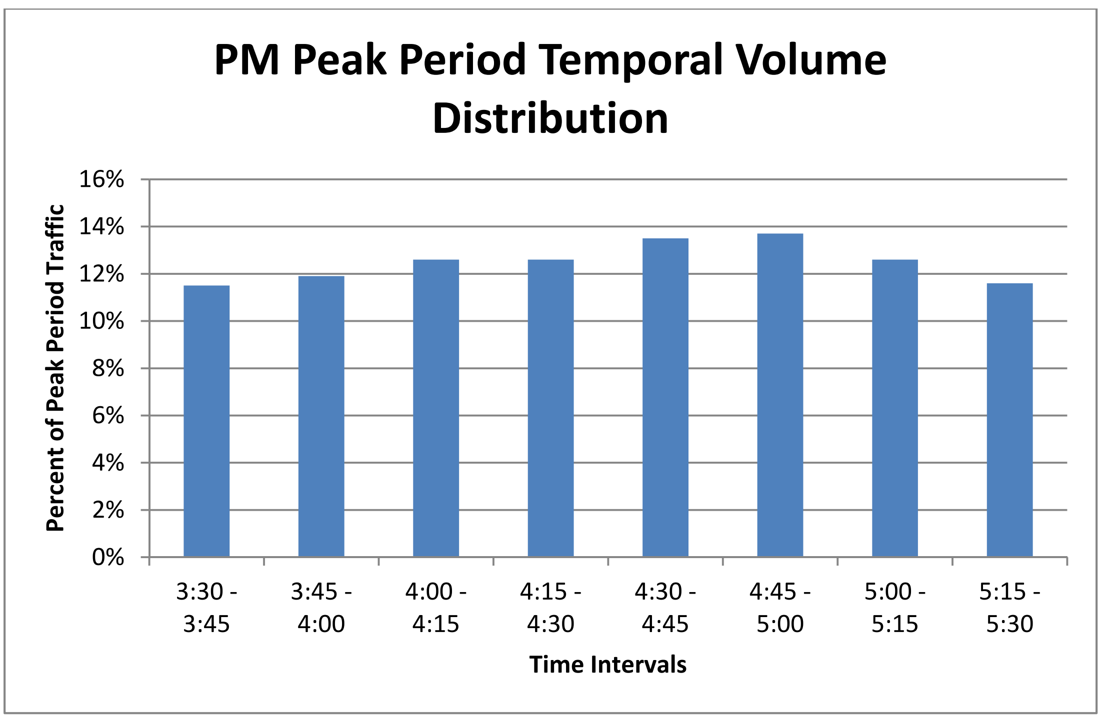

Figure 3: PM Peak Period Traffic Distribution

The o-d matrices included two hours of traffic data. Evaluation of the models was conducted over the entire two hours, although analysis statistics were calculated only for the peak hour.

Simulation models were built for the Base Year (2010) and for the Future Build scenario (2035) for RPA8.

TransModeler is able to gather output statistics during the simulation runs in order to analyze traffic flow conditions in the network. A variety of measures of effectiveness can be derived from these raw outputs in order to characterize the level of service in a network or in particular parts of a network. Output statistics range from basic measures of performance, such as average speed and flow, to more complex operational measures, such as intersection delay and queue lengths.

Outputs obtained for the Section 5 simulation model include speed data on the interchange ramps and certain sections of I-69; flow data; intersection delay; and queuing data. Three separate simulation runs were made for each simulated peak period. For each simulation run, a random seed was assigned by TransModeler. Because each simulation is a stochastic Monte Carlo[3] simulation, the results of each run will be different. The results for the three runs are aggregated together when reporting output statistics.

Base Year Simulation

The development of the Base Year simulation model was supported by local data collection and field observations. Field observations were made over a two-day period (mid-week) in October of 2012. The entire study area was observed in both the AM and PM peak periods, although particular attention was paid to SR 45 and SR 48. Observations were made via driven vehicle and with stationary observers.

Field observations included the following:

[3] Monte Carlo simulations use random numbers as a basis to forecast traffic conditions. The random number basis means that each simulation's results are independent of other simulations.

- Intersection geometry
- Presence of traffic signals
- Approximate signal cycles
- Traffic signal phasing
- Presence of advanced vehicle detection
- Protected left-turns
- Presence of right-turn-on-red restrictions
- Signal progression effects (or non-effects)
- Posted speed limits
- Queuing locations, durations, and intensity
- Lane utilization ratios
- Traffic conditions
- Directional traffic splits
- Travel times
- Driveway operations and their effect on mainline traffic

Turning movement counts were conducted at the following intersections:

- SR 37 / Victor Pike
- SR 37 / That Road
- SR 37 / Rockport Road
- SR 37 / Fullerton Pike
- SR 37 / Vernal Pike
- SR 37 / Kinser Pike
- SR 45 / Curry Pike
- SR 45 / Industrial Blvd / Wal-Mart
- SR 45 / Liberty Dr. / Hickory Leaf Dr.
- SR 45 / SR 37 SB Ramps
- SR 45 / SR 37 NB Ramps
- SR 45 / Basswood Dr. / Frontage Rd
- SR 48 / Curry Pike
- SR 48 / Liberty Dr. / Welmir Dr.
- SR 48 / Gates Dr. / K-Mart
- SR 48 / SR 37 SB Ramps
- SR 48 / SR 37 NB Ramps
- SR 48 / Wynndale Dr. / Franklin Dr.
- SR 37 / Whitehall Crossing Blvd

In addition, vehicle classification counts were conducted at the following mainline locations:

- SR 37 between SR 45 and SR 48
- SR 46 east of SR 37
- SR 46 west of SR 37
- SR 37 SB on-ramp from EB SR 46
- SR 37 SB on-ramp from WB SR 46
- SR 37 SB off-ramp to EB SR 46
- SR 37 NB off-ramp to EB SR 46
- SR 37 NB on-ramp from WB SR 46
- SR 37 NB on-ramp from EB SR 46
- SR 37 NB off-ramp to WB SR 46
- SR 37 SB off-ramp to WB SR 46

The turning movements and other traffic volumes were collected at the same time as the field observations. Other traffic volumes collected as part of the I-69 Corridor Model were also consulted as needed.

The functional classifications of the roadways used in the simulation model were matched to the classifications used in the Corridor Model. The TransModeler road class defaults (saturation flow rate, volume-delay function Alpha, volume-delay function Beta, etc.) were used for the roadways in the model. The only exception to the default parameters were the speed parameters, which were matched to the existing posted speed limits (free-flow speed was assumed to be higher than posted speed limits).

Existing traffic signal plans were provided by INDOT and the City of Bloomington for use in the Base Year simulation model. The signal progression and phase times were adjusted slightly so that modeled traffic conditions more closely matched observed conditions.

Future Build Simulation

The SR 46 and SR 48 interchanges were not modified from their existing geometries for the forecast year analyses. All other facilities that intersect with SR 37 were modified to reflect the future changes in access associated with the proposed design for I-69.

Besides the construction of I-69, the future build condition also includes improvements to Fullerton Pike, which is to be widened from two lanes to four lanes within the study area. This planned improvement is independent of the construction of I-69.

As stated before, the forecasted traffic volumes used for the Future Build simulation model come from exported o-d matrices produced by the I-69 Corridor Model.

New traffic signals were assumed to be present at the intersections of the Fullerton Pike interchange and the Tapp Road interchange. Future traffic signal timing, including phasing and progression offsets, were produced using the signal optimization methods found in Synchro 7. The signal timing plans were then used as the initial signal control plans. The timing and phasing were revised as necessary to improve traffic operations.

Geometric Summary

The geometry for the build network incorporated into the simulation model was taken directly from the initial design for the Refined Preferred Alternative. This includes the number of lanes on new and existing facilities, the presence of turn bays, associated S-lines, etc.

Throughout the simulation study area, I-69 was assumed to have three mainline lanes in each direction. Auxiliary lanes are present between SR 45 and SR 48 in the northbound direction and in the southbound direction between SR 45 and SR 48 and between Tapp Road and Fullerton Pike.

Initial Findings

The results from the simulation model indicate that traffic operations at the Fullerton Pike interchange, Tapp Road interchange, SR 45 interchange, and Walnut Street interchange operate adequately without major modification. The results for the SR 46 interchange indicate some future operational issues, and the results for the SR 48 interchange as initially designed indicated the need for a review of the design. A fuller description of initial results is below.

Fullerton Pike

The preferred alternative includes a double-folded diamond interchange (see Figure 4). It has southbound exit and entrance ramps in the interchange's northwest quadrant, and northbound entrance and exit ramps in the interchange's southeast quadrant. The modeled area extends slightly beyond the interchange's exit and entrance ramps.

The assumed geometry for the intersection of Fullerton Pike and the I-69 southbound ramps include a left-turn lane and right-turn lane from Fullerton Pike to access the southbound on-ramp, and a right-turn lane and left-turn lane from the southbound off-ramp to access Fullerton Pike. The southbound off-ramp was modeled with one lane that split into two lanes, and the southbound on-ramp was modeled with one lane.

The assumed geometry for the intersection of Fullerton Pike and the I-69 northbound ramps include a left-turn lane and right-turn lane from Fullerton Pike to access the northbound on-ramp, and a right-turn lane and left-turn lane from the northbound off-ramp to access Fullerton Pike. The northbound off-ramp was modeled with two lanes, and the northbound on-ramp was modeled with one lane.

This interchange is forecasted to provide acceptable operating conditions for all movements in the forecast year, in both the AM and PM peak periods. No queues are expected to impact operations on mainline sections.

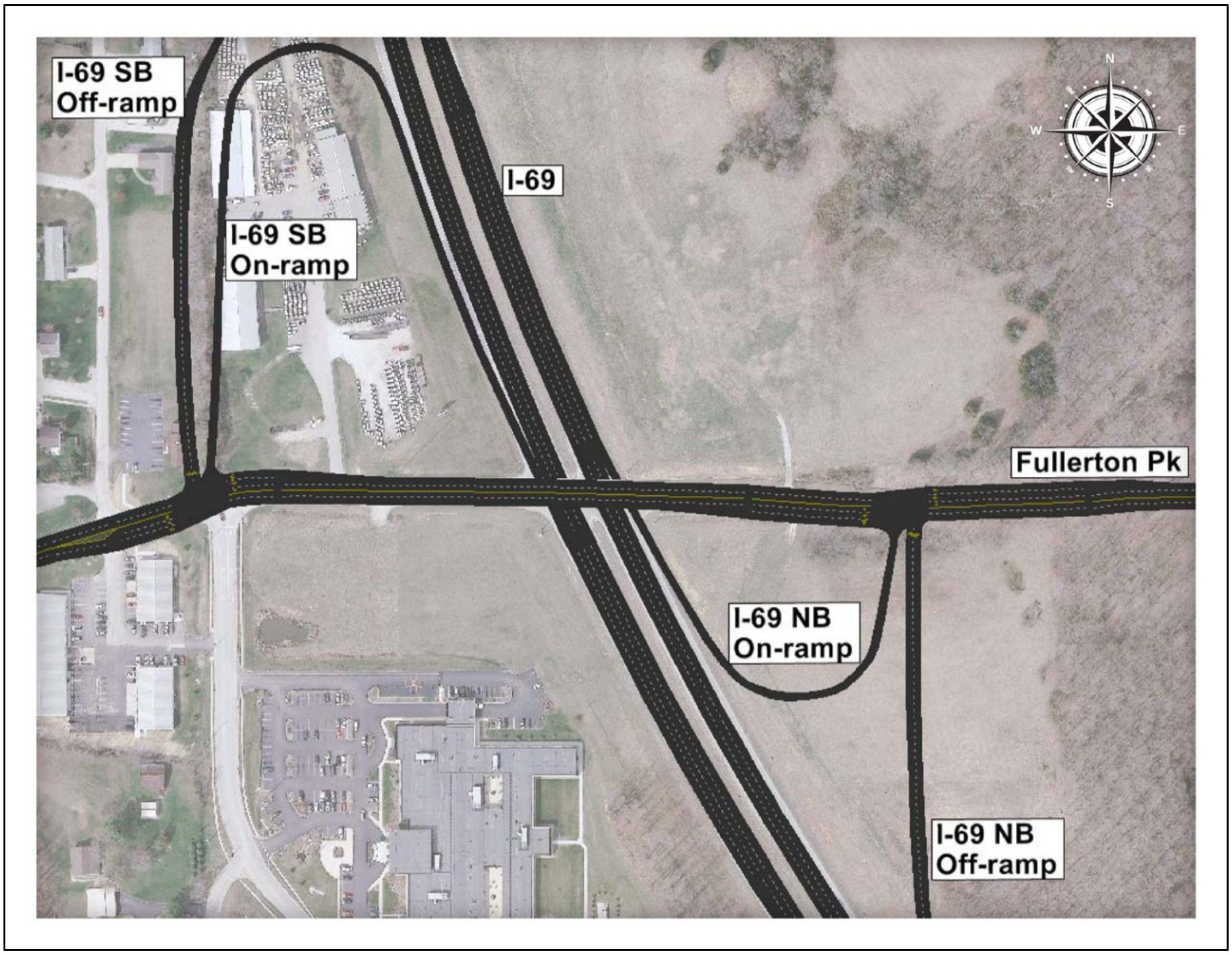

Figure 4: Fullerton Pike Interchange

Tapp Road – SR 45 Split Diamond

The preferred alternative includes a split-diamond interchange serving both Tapp Road and SR 45. Figure 5 shows the proposed interchange with Tapp Road. Northbound traffic exiting from I-69 to either Tapp Road or SR 45 uses an exit ramp located in the southeast quadrant of the Tapp Road/I-69 interchange. Traffic exiting to Tapp Road turns left or right where this ramp intersects Tapp Road (at a signalized intersection); traffic exiting to SR 45 continues through the signalized intersection, uses an access road which runs alongside NB I-69, and continues onto a ramp connecting to SR 45. At this point, traffic turns either left or right at a signalized intersection.

I-69 northbound traffic entering from Tapp Road enters the northbound ramp, and uses the access road which runs alongside northbound I-69, and continues to the ramp connecting to SR 45. After it passes through the signalized intersection of this ramp with SR 45, it continues onto the northbound entrance ramp to access I-69. Northbound entering traffic at SR 45 also uses this entrance ramp to access I-69. See Figure 8.

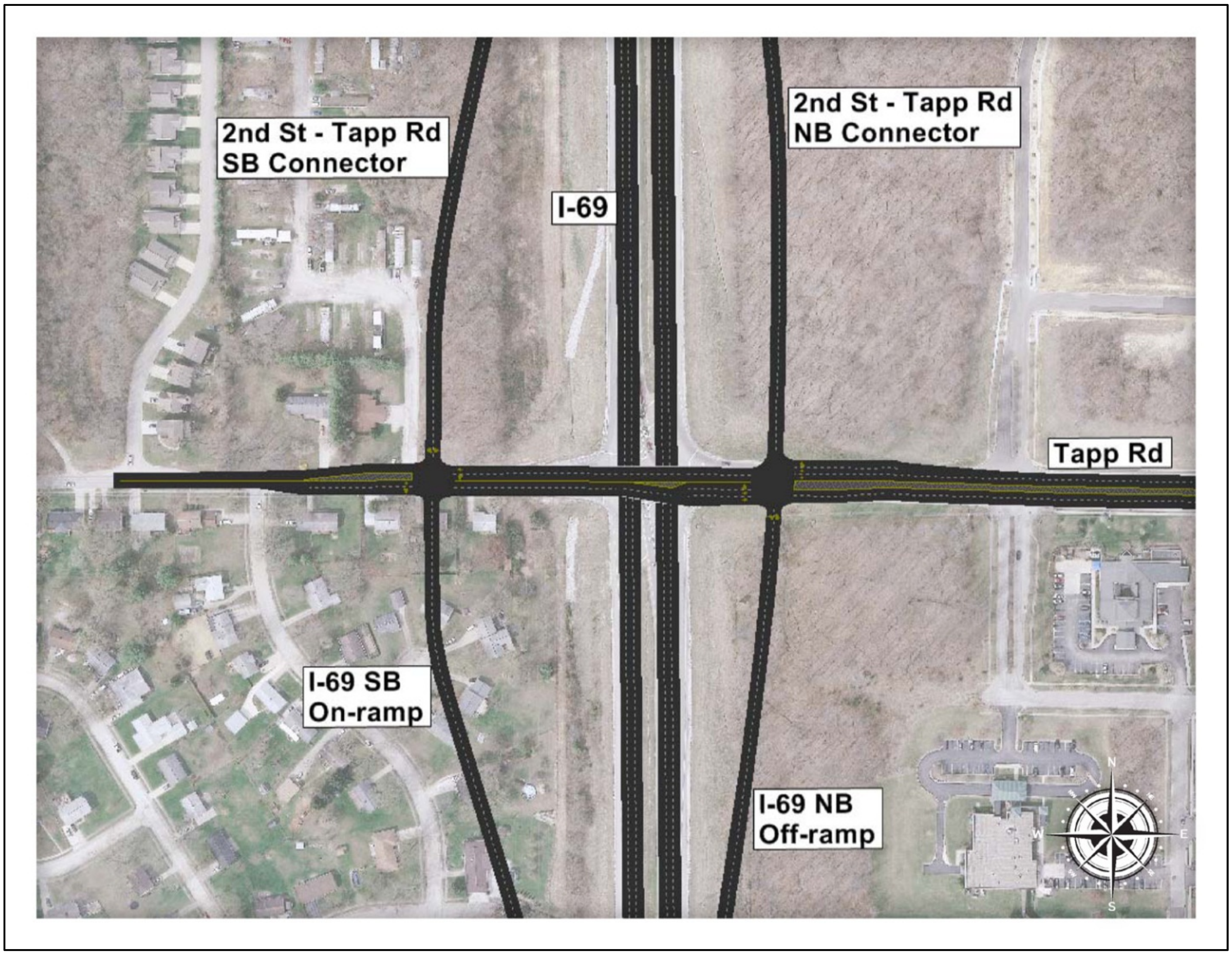

Figure 5: Tapp Road split Interchange

Southbound traffic exiting from I-69 to either SR 45 or Tapp Road uses an exit ramp located in the northwest quadrant of the SR 45/I-69 interchange. See Figure 7. Traffic exiting to SR 45 turns left or right where this ramp intersects SR 45 (at a signalized intersection); traffic exiting to Tapp Road continues through the signalized intersection, uses an access road which runs alongside southbound I-69, and continues onto a ramp connecting to Tapp Road. At this point, traffic turns either left or right at a signalized intersection.

I-69 southbound traffic entering from SR 45 enters the southbound ramp, and uses the access road which runs alongside southbound I-69, and continues to the ramp connecting to Tapp Road. After it passes through the signalized intersection of this ramp with Tapp Road, it continues onto the southbound entrance ramp to access I-69. Southbound entering traffic at Tapp Road also uses this entrance ramp to access I-69.

At Tapp Road, the modeled area includes the area immediately around the interchange.

At SR 45, the modeled area extends to the west past Curry Pike, and incorporates all intersections with SR 45 in this area. It also includes Liberty Drive in its entirety between SR 45 and SR 48. To the east, the modeled area extends to the intersection of SR 45 and Basswood Drive/Frontage Road. Figures 6 through 8 show SR 45 west of the proposed interchange and the interchange itself.

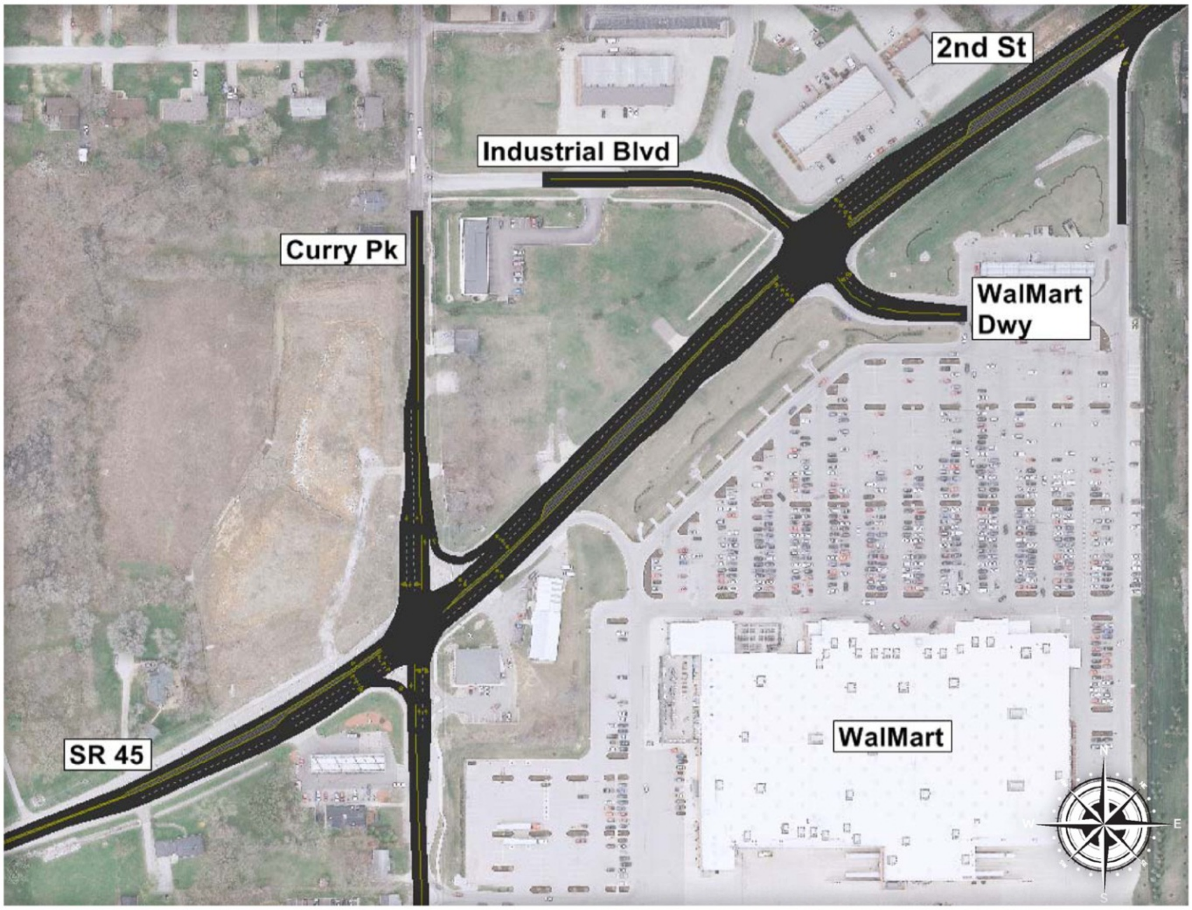

Figure 6: SR 45 west of I-69 Interchange

The assumed geometry for the intersection of Tapp Road and the I-69 southbound ramps include a left-turn lane and right-turn lane from Tapp Road to access the southbound on-ramp, and a through-right lane and left-turn lane from the southbound off-ramp to access Tapp Road and the southbound on-ramp. The southbound off-ramp and southbound on-ramp were both modeled with two lanes. Tapp Road in the westbound direction was modeled with two lanes approaching the intersection but with one lane departing. The westbound left-turn lane is, therefore, a “trap” lane, where traffic using it must turn left, and the lane is not continued to the west of the intersection.

The assumed geometry for the intersection of Tapp Road and the I-69 northbound ramps include a left-turn lane and right-turn lane from Tapp Road to access the northbound on-ramp, and a through-right lane and left-turn lane from the northbound off-ramp to access Tapp Road and the northbound on-ramp. The southbound off-ramp and southbound on-ramp were both modeled with two lanes. Tapp Road was assumed to be a have a four-lane cross section at this intersection.

Figure 7: SR 45 Interchange, west

The assumed geometry for the intersection of SR 45 and the I-69 southbound ramps includes many existing elements as well as some which would be constructed in the future. The southbound off-ramp would be widened from one lane to two lanes. The existing southbound right-turn slip lane would be maintained. The two-lane approach was assumed to include a through lane and a through-left lane. The westbound approach on SR 45 would be maintained. The eastbound approach was modified to include a right-turn slip lane for access to the southbound ramp. The southbound ramp would have two lanes.

The assumed geometry for the intersection of SR 45 and the I-69 northbound ramps also includes many elements existing elements as well as some which would constructed in the future. See Figure 8. The northbound off-ramp was modeled with two lanes on the main section and with three lanes on the direct approach to SR 45. The northbound approach was modeled with a left-turn lane and a right-turn lane for access to SR 45 and with a through lane for access to the northbound on-ramp. The eastbound and westbound approaches on SR 45 would be maintained. The northbound on-ramp existing cross-section would be maintained.

Figure 8: SR 45 Interchange, east

The intersections of SR 45 with Curry Pike, Industrial Boulevard, Liberty Drive, and Basswood Drive were modeled with their existing configuration. See Figures 6 and 8.

The simulation model included the assumption that a new driveway would be constructed to serve the Sam's Club property. Under the existing conditions, access to Sam's Club is provided as the south leg of the SR 45/SR 37 southbound ramps intersection. However, the preferred alternative includes an access road to Tapp Road in that space. The new driveway was added to the simulation model between Liberty Drive and the I-69 southbound ramps. The location was chosen based on probable access to existing circulation roadways in the Sam's Club parking lot. The intersection of SR 45 with this new driveway was assumed to have a left-turn lane from SR

45 for access to the driveway (but without a separate right-turn lane for access to the driveway). The driveway was modeled with a left-turn lane and a right-turn lane.

This interchange is forecasted to provide acceptable operating conditions for all movements in the forecast year, in both the AM and PM peak periods. No queues are expected to impact operations on mainline sections. Additionally consideration of further design modifications at the SR 45/Sam's Club entrance and SR 45/Curry Pike is recommended. These design considerations are recommended to assure efficient movements in the forecast year.

SR 48

The Preferred Alternative reuses the existing interchange of SR 37 at SR 48. This interchange is an urban tight diamond (see Figures 9 and 10).

The modeled area extends to the west past Curry Pike. It includes the intersection with Liberty Drive, which is included in its entirety to its connection to SR 48. It also includes the intersection with Gates Drive. The modeled area extends to the east to Franklin Road.

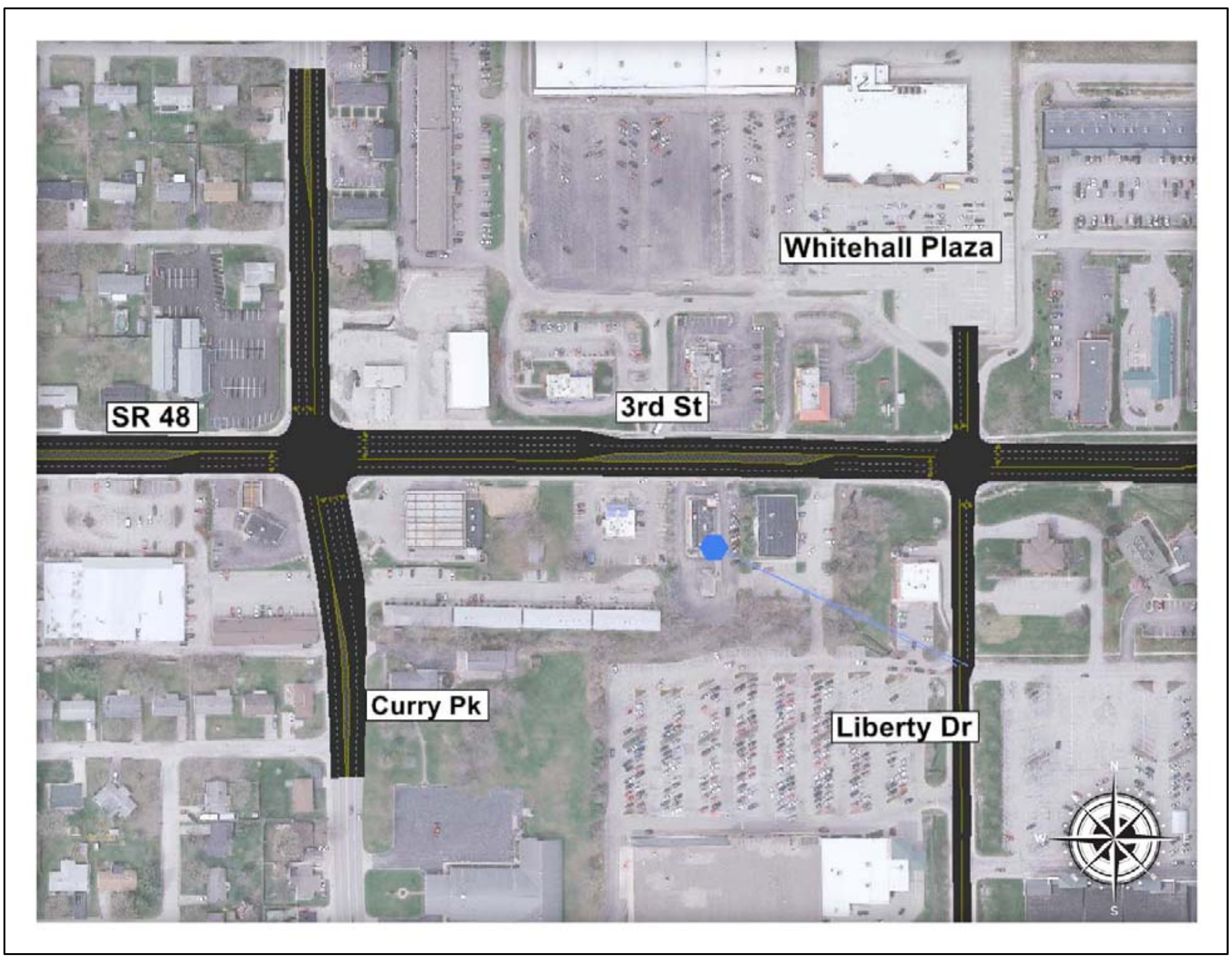

Figure 9: SR 48 west of I-69 Interchange

The initial simulation model included no alternations to the intersections along 3rd St. Simulation model results showed poor traffic operations at both the northbound and southbound ramp junctions. See "Design Alternatives – SR 48 Interchange" section following for a description of poor traffic conditions for existing interchange reuse, as well as alternative designs which were evaluated to alleviate these conditions.

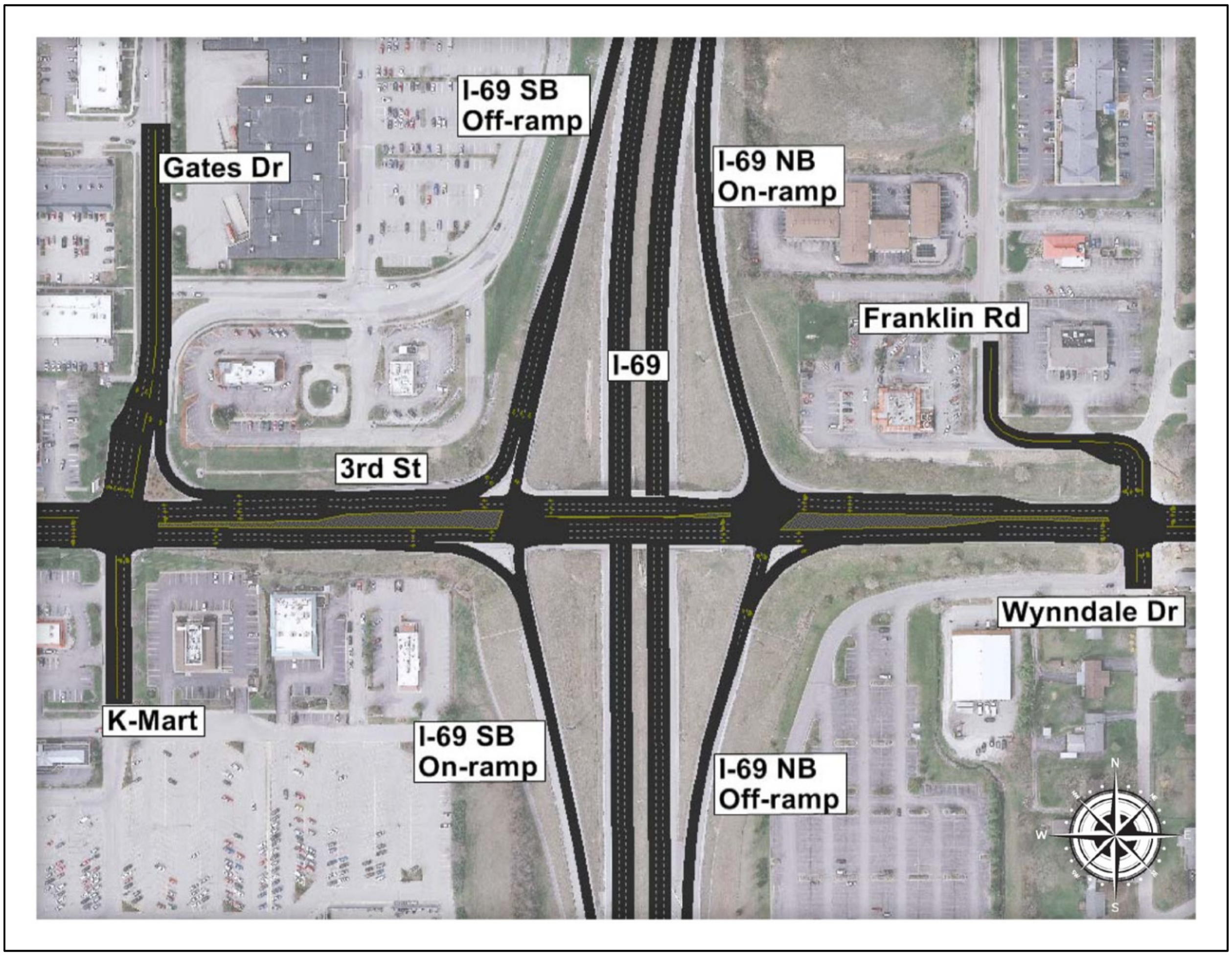

Figure 10: SR 48 Interchange

SR 46

The Preferred Alternative reuses the existing interchange of SR 37 and SR 46 (see Figure 11). This interchange was constructed in the mid-1990's as part of the relocation of SR 46. Its design anticipates its use by I-69.

The modeled area extends to either side of the interchange approximately one-half mile, although there are no intersecting roads in this area.

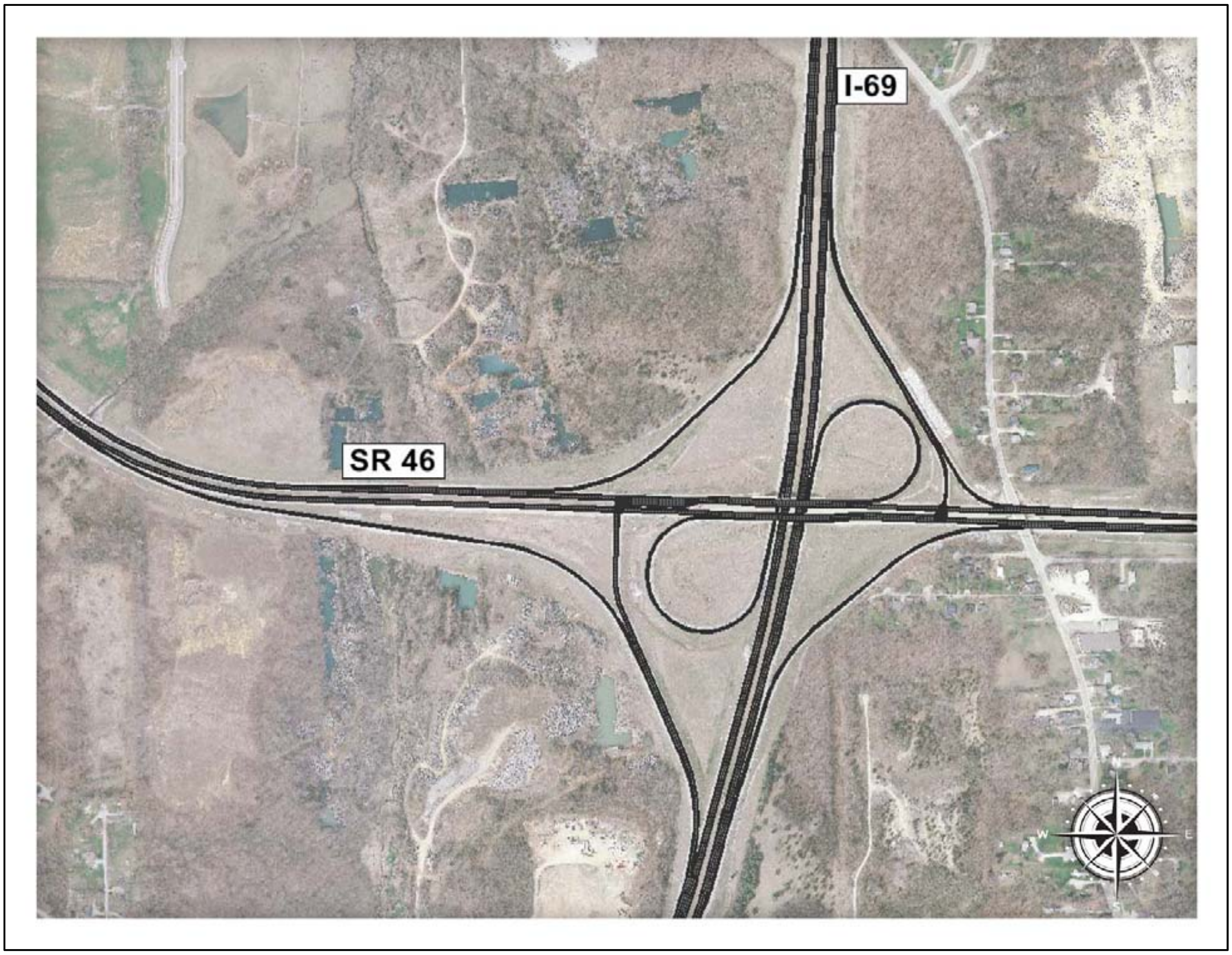

Figure 11: SR 46 Interchange

The SR 46 interchange generally operates adequately. The SR 46 interchange has only two points where there are traffic conflicts: a left-turn for westbound traffic on SR 46 to enter the southbound I-69 on-ramp; and a left-turn for eastbound traffic to enter the northbound I-69 on-ramp. The former point is controlled by an existing traffic signal, while the latter point is uncontrolled. At this uncontrolled intersection queues in the left-turn lane showed a tendency to spill back into the mainline lanes. Adding a second signal at this interchange for the may be required prior to the forecast year. Otherwise, this interchange is forecasted to provide acceptable operating conditions for all movements in the forecast year, in both the AM and PM peak periods.

Walnut Street

The Preferred Alternative includes the existing partial interchange of Walnut Street with SR 37 (see Figure 12). This interchange provides a southbound exiting and northbound entering movement to and from North Walnut Street.

Figure 12: Walnut Street Interchange

The modeled area extends to the south along Walnut St. approximately one-fifth mile, although there are no intersecting public roads in this area.

Because this interchange will continue as a free-flowing on-off movement with no cross-streets in the immediate vicinity of the interchange, it is shown as continuing to operate in free-flow conditions and within acceptable standards in the forecast year.

Design Alternatives – SR 48 Interchange

In the simulation model results for the SR 48 interchange showed poor traffic operations at the both the northbound and southbound ramp junction locations. The northbound off-ramp in particular showed extensive queuing. Due to the relatively short length of the northbound off-ramp, and the attendant limited storage space for vehicles, queuing on the northbound off-ramp extended onto the auxiliary lane of I-69 and some distance toward the SR 45 interchange.

The built-up nature of the area around the SR 48 interchange constrains capacity expansion alternatives at the interchange. The land surrounding the interchange generally is fully developed, and an existing railroad overpass on the south side of the interchange means that lengthening the existing northbound off-ramp would require altering the railroad bridge structure. These constraints guided the initial plan for the interchange (which was to reuse it without alteration).

Two alternate designs were created and tested within the simulation model. Both alternative designs reflect the above-cited physical restrictions. That is, there was no expansion of I-69 or its ramps south of the railroad bridge, and all other expansion takes place to the extent possible within existing ROW. The first tested alternative was to replace the existing diamond configuration with a single-point urban interchange (SPUI), and the second tested alternative was to "maximize" the capacity of the existing diamond configuration (called the expanded diamond below).

SPUI

The SPUI, as simulated, would have the northbound I-69 off-ramp expand to three lanes nearly immediately north of the railroad bridge structure (see Figure 13). There would be double left-turns on SR 48 to both the southbound and northbound on-ramps. The SPUI would also have double-left lanes on the northbound and southbound off-ramps for traffic entering SR 48. Every right-turn movement at the SPUI would be made using slip lanes[4].

The simulation model indicated that the SR 48 interchange would operate adequately in the future build condition when designed as a SPUI. The widened northbound off-ramp provides sufficient storage to prevent queues from backing up onto the mainline section of I-69. The single signalized location (replacing the two closely-spaced signals in the diamond configuration) provides efficient traffic operations on SR 48 while also increasing the storage space to the nearest side street intersections (Gates Drive to the west and Franklin Street/Wynndale Drive to the east).

[4] Slip lane refers to a turn lane that turns from the mainline prior to an intersection and, thus, avoids whatever traffic control is in place at the intersection. The radius of a slip lane will also allow vehicles to turn at greater speeds than from a standard turn lane.

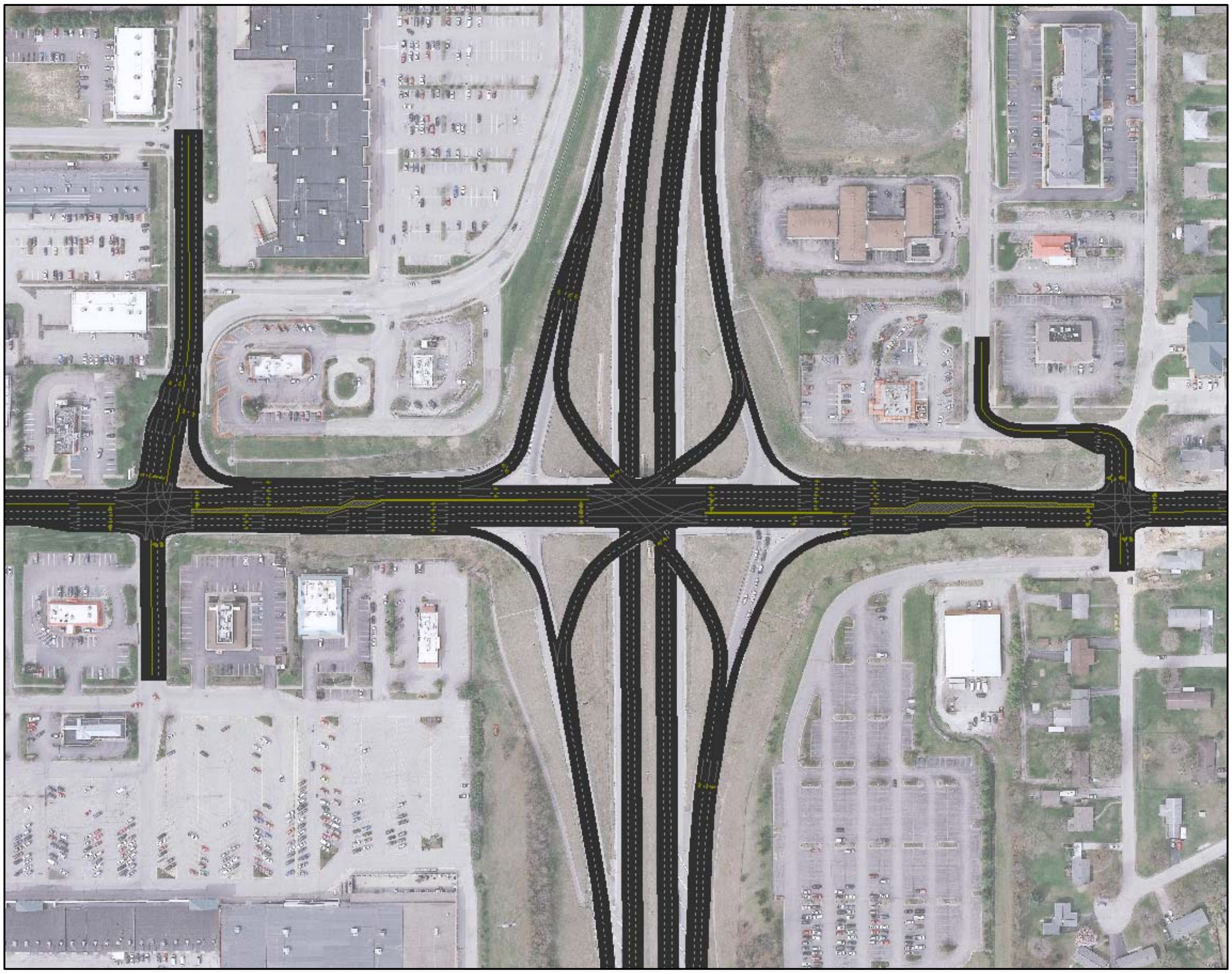

Figure 13: SR 48 SPUI Interchange Concept

Expanded Diamond

The expanded diamond interchange was simulated to include the realistic maximum capacity possible at the interchange while maintaining the diamond configuration (see Figure 14). As with the SPUI, the northbound off-ramp was simulated to show widening to three lanes just north of the railroad bridge. The existing SR 48 structure over SR 37/I-69 was widened to allow a double-left turn lane from westbound SR 48 traffic onto the southbound on-ramp. The southbound off-ramp was widened to allow a double-left turn lane, and the storage space on the ramp was also increased. SR 48 itself was also widened on either side of the interchange to allow for more storage at the signals.

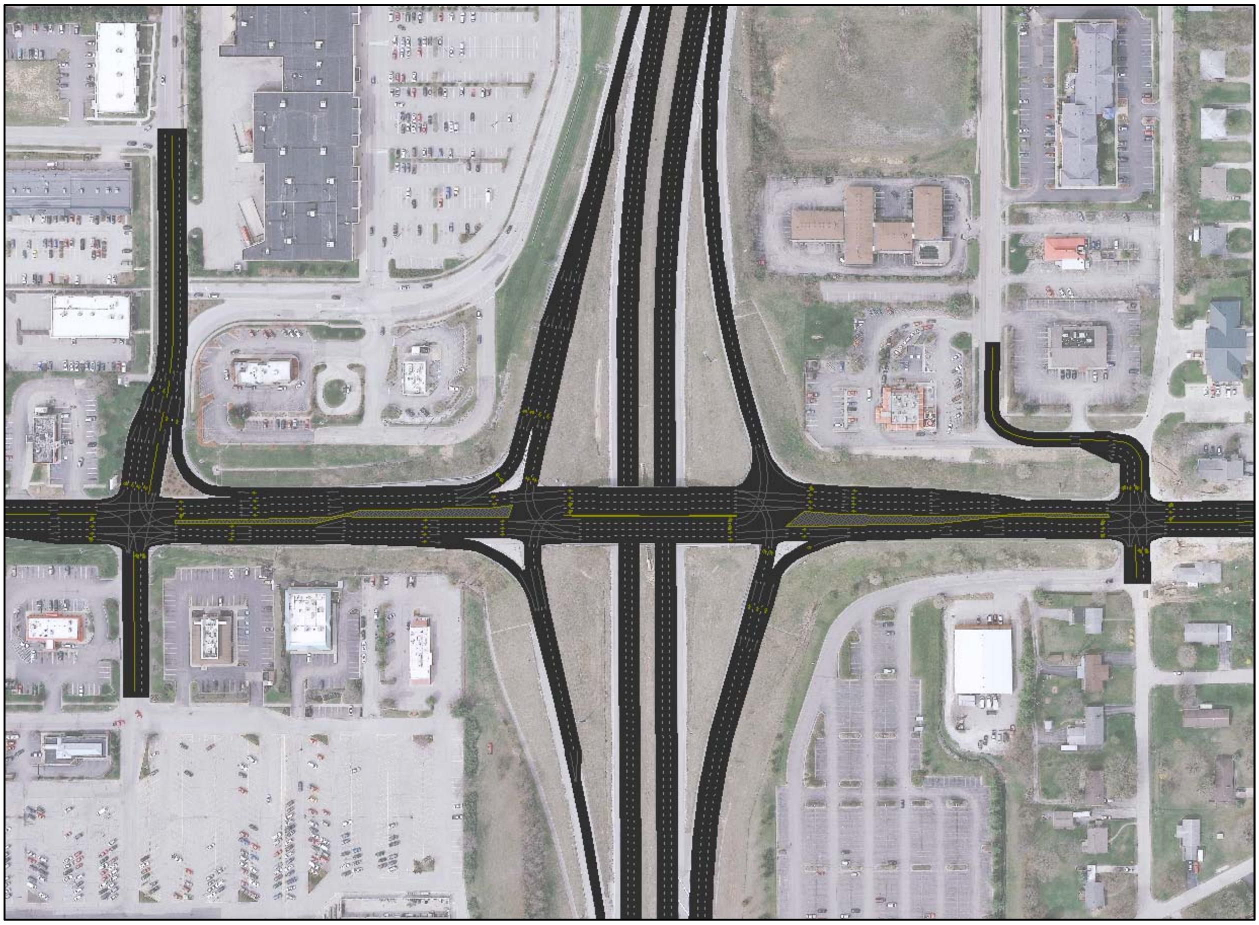

Figure 14: SR 48 Expanded Interchange

The simulation model indicated that the SR 48 interchange would operate adequately in the future build condition when designed as an expanded diamond. The widened northbound off-ramp provides sufficient storage to prevent queues from backing up onto the mainline section of I-69. The increased capacity and increased storage at the ramp signalized intersections serve to improve the traffic operations on SR 48.

Conclusions

While both alternative designs at SR 48 adequate served forecasted traffic levels, the expanded diamond interchange was recommended for inclusion into the Refined Preferred Alternative. The expanded diamond was chosen because construction costs would be considerably less than the cost of construction of a SPUI, and there would be less disruption to local traffic during construction.

The exact lengths, widths, and radii of the interchange elements (including off-ramps, on-ramps, turn lanes, transition tapers, etc.) will be determined during design. It should be emphasized that the simulation model is used here as a diagnostic tool and not a design tool. Furthermore, the final design may not incorporate all of the elements included in the simulation.